



Understanding Your Utility Bills:

 Electricity

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Senthil Sundaramoorthy
Subodh Chaudhari
Thomas Wenning**



Meeting Recording Announcement

This Zoom call is being recorded and may be posted on DOE's website or used internally. If you do not wish to have your voice recorded, please do not speak during the call or disconnect now. If you do not wish to have your image recorded, please turn off your camera or participate only by phone. If you speak during the call or use a video connection, you are presumed to consent to recording and to the use of your voice or image.

U.S. DEPARTMENT OF
ENERGY

Energy Awareness Month

Webinar Series with DOE's
Better Plants Program

Oct 7th - 28th, 2021

1:00pm US-EST / 11:00am US-EST



- Saving Energy For Small to Medium Manufacturers
- Energy Intensity Baseline and Tracking
- Understanding your Utility Bills: Electric, Water, Natural Gas
- Lessons from Better Plants Goal Achievers

[Yesevents.com/EnergyAwareness](https://yesevents.com/EnergyAwareness)



Energy Awareness Month Webinar Schedule

Date	Title
Thursday, Oct 7, 1pm – 2pm ET:	Quick Start Guide to Saving Energy for Small to Medium Manufacturers
Tuesday, Oct 12, 11am – 12pm ET	The Updated Energy Intensity Baseline and Tracking Guide
Thursday, Oct 14, 1pm – 2pm ET	Understanding Your Electricity Bills
Tuesday, Oct 19, 11am – 12pm ET	Understanding Your Natural Gas Bills
Tuesday, Oct 26, 11am – 12pm ET	Understanding Your Water Bills
Thursday, Oct 28, 1pm – 2pm ET	Lessons Learned From Goal Achievers

[Yesevents.com/EnergyAwareness](https://yesevents.com/EnergyAwareness)



Engaging with DOE

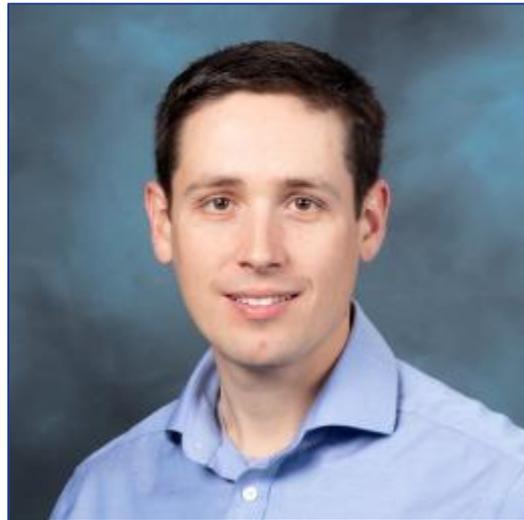
- Have questions? Please use the Zoom chat!
- Want to learn more? energy.gov/BBSC

The screenshot displays the Better Buildings website interface. At the top left is the Better Buildings logo with the text 'U.S. DEPARTMENT OF ENERGY'. To the right is a search bar labeled 'SEARCH SOLUTIONS' and social media icons for Twitter, LinkedIn, Facebook, and Email. Below the logo is a navigation menu with categories: SOLUTIONS, PROGRAMS & PARTNERS (highlighted in green), EVENTS & WEBINARS, and LEARN MORE. Underneath are sub-categories: EXPLORE BY TOPIC, BROWSE SOLUTION TYPES, TOOLKITS, FINANCING NAVIGATOR, RESILIENCE, CHP, RENEWABLES, and COVID-19. A small notification for 'Renewables' is visible. The main content area is titled 'BETTER PLANTS RESOURCE LIBRARY' and features a 'Better Plants Essentials' section. On the left is an image of industrial machinery. The essentials list includes:

- [Better Plants Program Overview](#)
- [Better Plants Challenge Overview](#)
- [Annual Data Reporting Form](#)
- [Partnership Agreement Form - Better Plants Program](#)
- [Partnership Agreement Form - Better Plants Challenge](#)
- [Energy Intensity Baseline and Tracking Summary](#)
- [Quick Start Guide for Small to Medium Manufacturers](#)
- [Better Plants Challenge Guide](#)
- [Energy Intensity Baseline and Tracking Guide](#)
- [Valuable Tools and Resources from Better Plants](#)
- [Science-Based Targets Guide](#)
- [Trailblazers and Goal Achievers: How Better Plants Partners Achieved Ambitious Energy Goals](#)
- [Understanding Your Utility Bills: Electricity](#)
- [Understanding Your Utility Bills: Natural Gas](#)
- [Understanding Your Utility Bills: Water](#)
- [Energy Management During a Pandemic](#)



Today's Presenter



Dr. Christopher Price
Oak Ridge National Laboratory



About Better Buildings, Better Plants

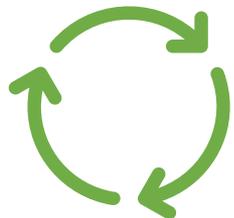
Helping manufacturers and other industrial partners save money and improve their resource efficiency.



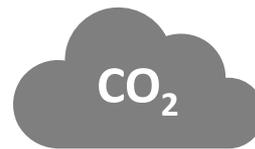
Increased
Energy
Productivity



Greater
Water
Savings



Improved
Waste
Reduction



Lower
Carbon
Emissions



Better Plants Resources

NO-COST SOFTWARE & TOOLS

Access to no-cost software and tools to identify and implement energy saving opportunities and manage energy use.



60+
Calculators



20+ No-Cost
Tools for Loan



Financing
Navigator



No-Cost Resources
& Guides

TRAINING & EDUCATION



**In-Plant Trainings
Conducted to Date**

Multi-day trainings for staff to identify, implement, and replicate energy savings projects.



**No-Cost Webinars
& Growing**

RECOGNITION



49 Better Project &
Better Practice Winners

For innovative and industry-leading accomplishments in implementing and promoting company-wide practices, principles, and procedures of energy management, as well as improvement projects at individual facilities.



59
Goal
Achievers



**National Recognition
in Media and Online**



**Solutions on
Solution Center**

INNOVATION & LABS



17 National Labs
Across the Country

Partnerships with the National Labs spurs innovation.



**Lab Technology
Days**

Snead peek at early-stage R&D Technologies



**Field
Validation**

A new pilot for partners to accelerate the voluntary adoption of cost-effective, high-impact technologies while reducing adoption risks.

What Leadership Looks Like

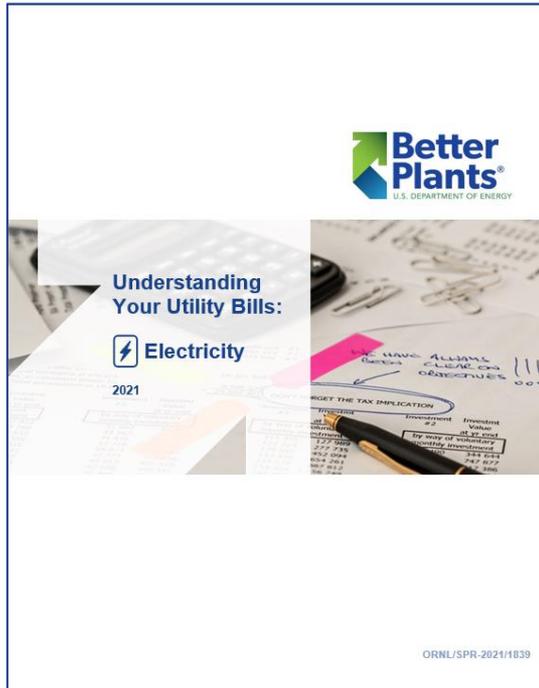
250+ partners across the United States and territories



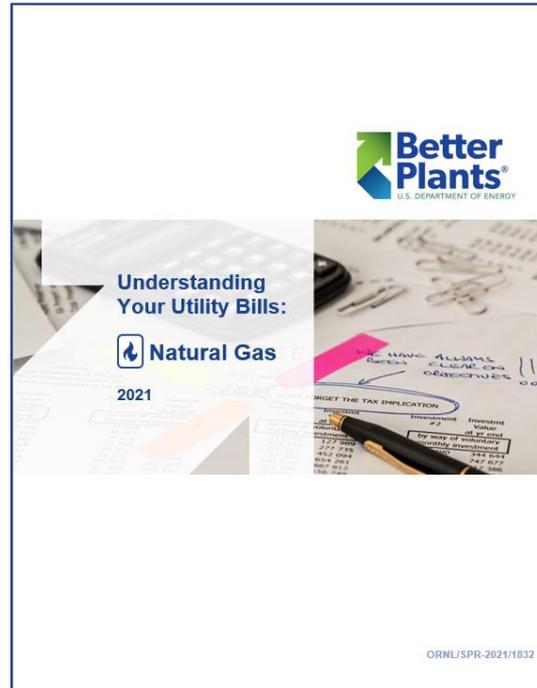


Understanding your Utility Bills

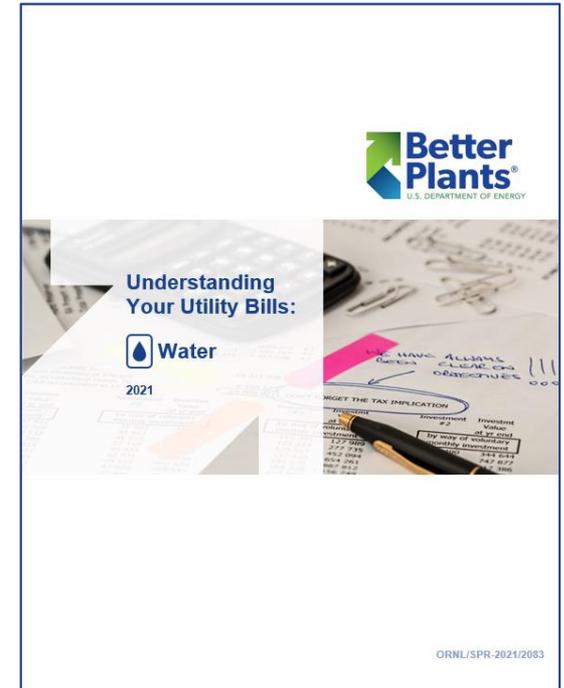
Just one in a series of guidance documents:



Electricity Bills



Natural Gas Bills

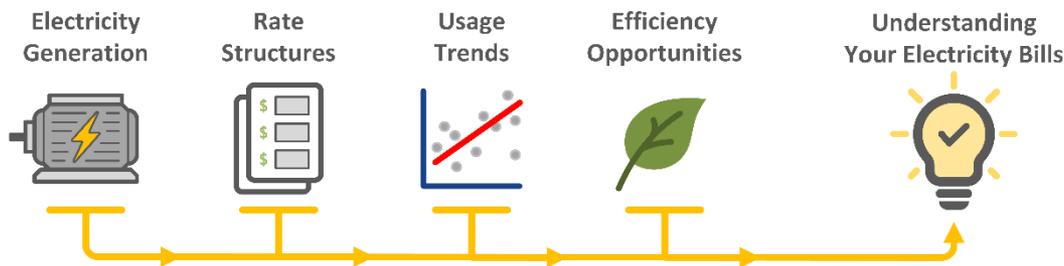


Water Bills



Using the Guide

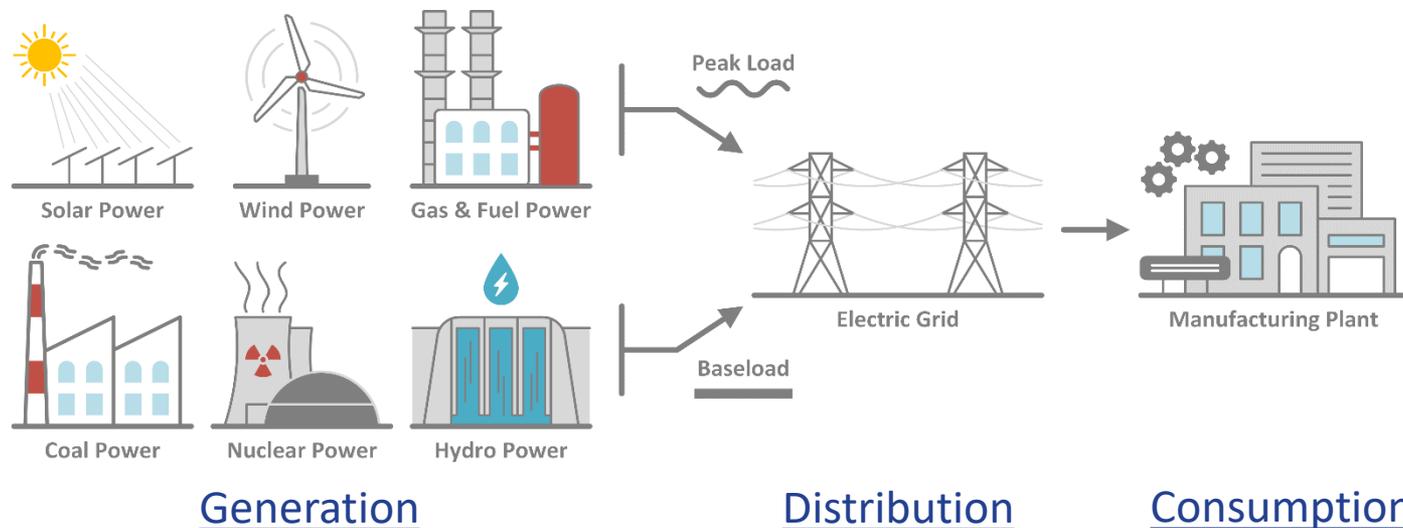
- Electricity bills can be hard to decipher
- Some bills can be very detailed, some are very short
- Some charges appear each month, some do not
- Understanding your bills and why your utility charges different fees is important to save energy and cost
- The guide covers the basics of electricity bills:





How is Electricity Generated?

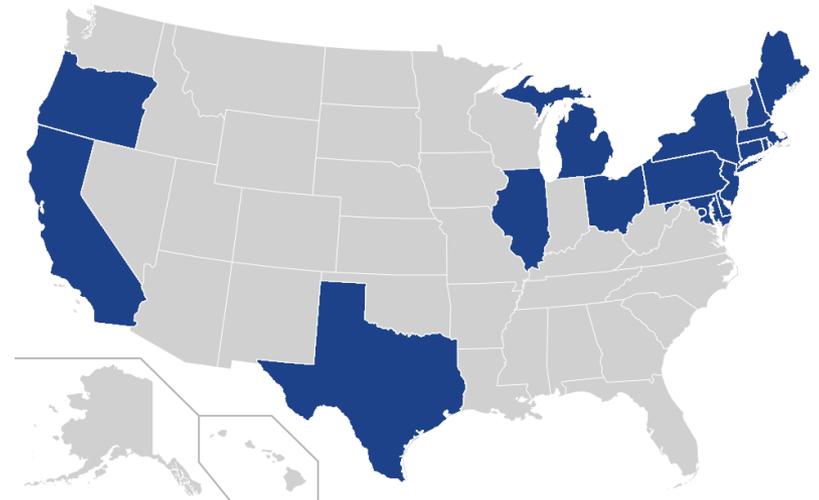
- Electricity comes from many different sources
- The mix of electricity sources is changing
- Power is delivered to your facility through the **Grid**
- Generating costs are different for each source





What are Deregulated Power Markets?

- **Regulated Power Markets:** Utilities own and maintain all the equipment from generator to your meter
- **Deregulated Power Market:** Generators and distributors are separate entities
- Deregulation is meant to:
 - (1) Lower energy costs through competition
 - (2) Promote green energy
- May get multiple bills
- Currently 15 States + DC





Key Components to Your Electricity Bills

> Date Billed: 3/26/2020
> Account #: 1234-5678
> Invoice: 32620-12345

BETTER PLANTS ELECTRIC INC

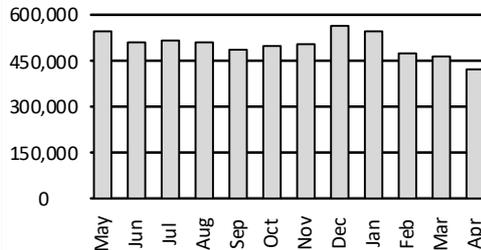
Here to help you save.



Total Amount Due by 4/1/2020 \$32,446.48

Service for:
Manufacturing Plant
987 Sixth Avenue
Oak Ridge, TN 37830

Meter #: J942U4L71
Days on Bill: 30
Total kWh: 421,855
Billed Demand: 1,257 kW
Actual Demand: 1,151 kW
PF: 0.87



Customer Charge:		\$45.00
Metering Charge		\$175.00
Energy Charge 1:	250,000 x 0.0625	\$15,625.00
Energy Charge 2:	171,855 x 0.0482	\$8,283.41
Energy Efficiency Cost Recovery:	421,855 x 0.0004	\$168.74
Transmission Charge 1:	1,257 x 2.2582	\$2,838.56
Transmission Charge 2:	1,257 x 0.3247	\$408.15
Transmission Cost Recovery:	1,257 x 2.4849	\$3,123.52
Nuclear Decommissioning:	1,257 x 0.0079	\$9.93
Distribution Cost Recovery:	1,257 x 0.4594	\$577.47
PF Penalty:	106 x 5.5351	\$586.72

Energy Subtotal: \$31,841.49

Local Sales Tax:	0.25%	\$79.60
State Sales Tax:	1.65%	\$525.38
Late Payment Fee:		\$0.00

Taxes & Fees Subtotal: \$604.99

Meter Number ①

Meter Readings ②

Power Factor ③

④ Fixed Charges

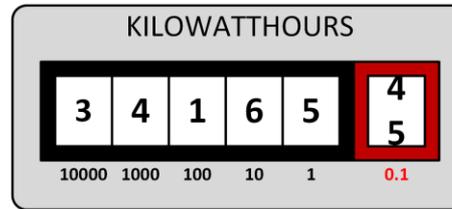
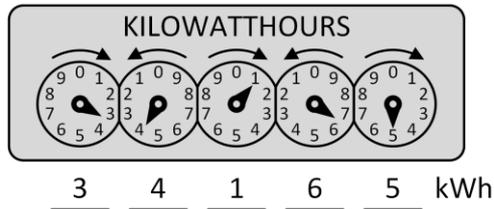
⑤ Consumption Charges

⑥ Demand Charges

⑦ Taxes, Fees, & Penalties



Consumption Charges



- Electricity **Consumption** or **usage** is the total amount of electricity your facility uses to make products
- Measured in kilowatt-hours (kWh) which is equal to 1 kilowatt of power sustained for 1 hour
- Can appear on your bills as energy charge, energy cost, delivered energy cost, etc.
- Billed at a rate (\$/kWh) determined by your contract



Demand Charges

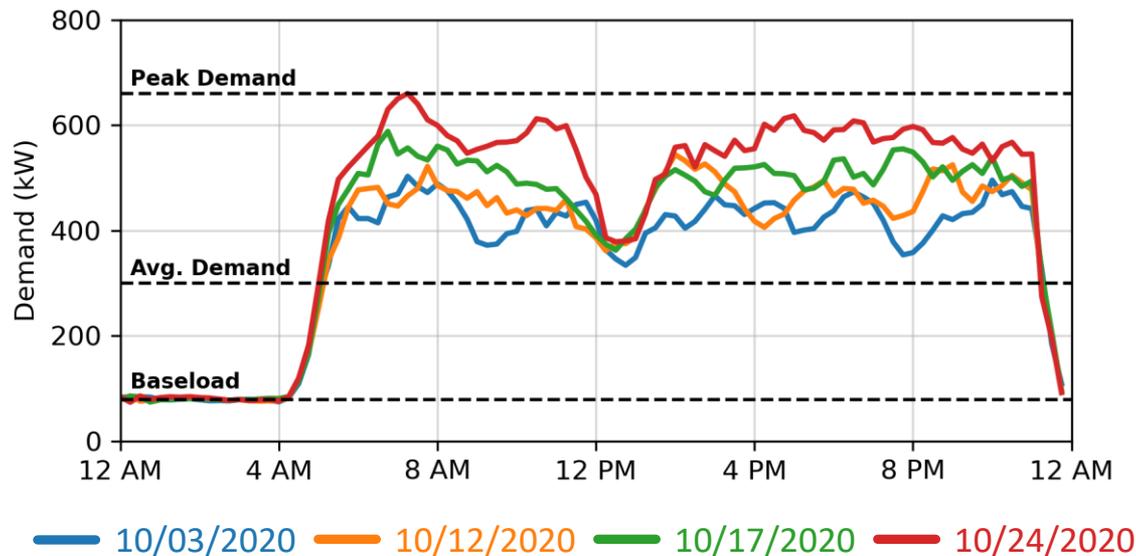
- Industrial facilities also charged for ***Electrical Demand***
- Demand measures the rate of electricity consumption
- Calculated by averaging consumption over a window:

$$\frac{25 \text{ kWh}}{15 \text{ minutes}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} = 100 \text{ kW}$$

- More demand means more grid infrastructure your utility must build and maintain to deliver power
- Can appear on your bills as demand charge, demand cost, transmissions and delivery (T&D) charge, etc.

Types of Demand Charges

- Your facility's demand will vary over a typical day
- You are billed based on the monthly **Peak Demand**
- One demand spike can set your charges for months!

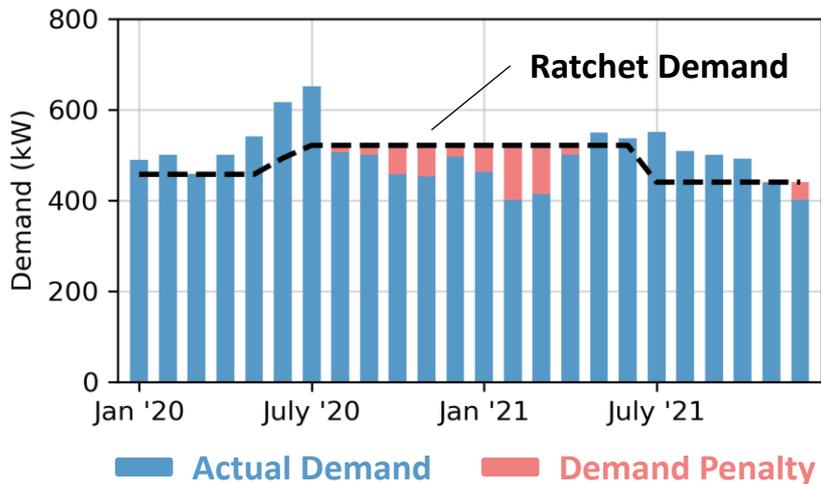


Types of Demand Charges

- **Actual Demand** is observed peak from the last month
- **Billed Demand** is an adjustment to your real demand established by clauses in your electricity rate schedule

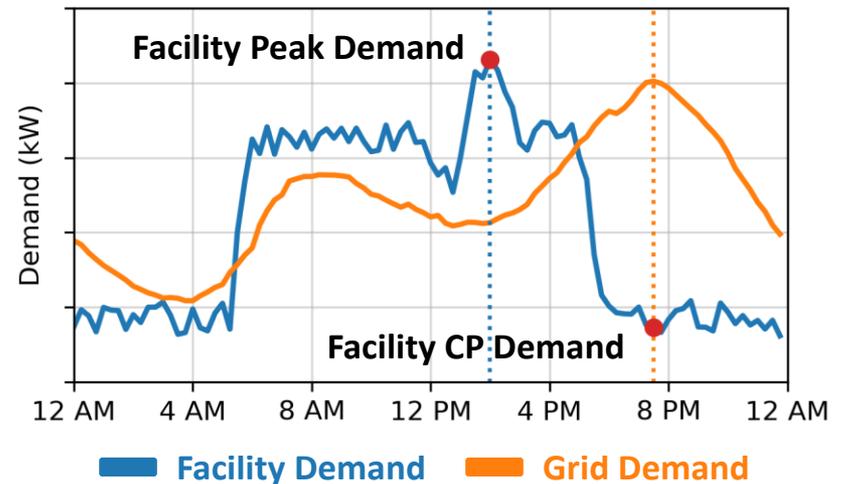
Ratchet Clauses

“80% of max demand from last 12 months”



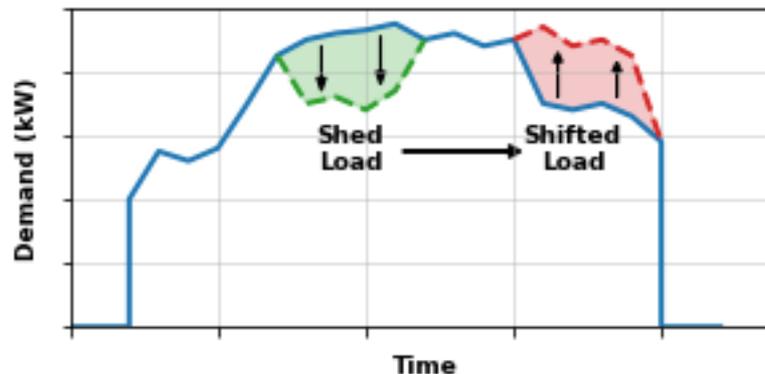
Coincident Peak (CP) Clauses

“Facility demand when grid hits its peak”



Managing Your Demand

- Lowering your demand costs means managing your facility's load profile
- Two main strategies:
 - 1) **Load Shedding**: A temporary reduction in demand
 - 2) **Load Shifting**: A transfer of load to off-peak hours



- Some utilities offer **Demand Response** incentives to shed or shift load during high grid stress events



Power Factor Penalties

- The way AC power interacts with your equipment affects how much power your utility must deliver
- This effect is captured by your **Power Factor (PF)**
- Most utilities will penalize you for having a low PF
- PF is inherent to AC circuits, but it can be managed!

$$V(t) = V \cdot \cos(\omega t)$$

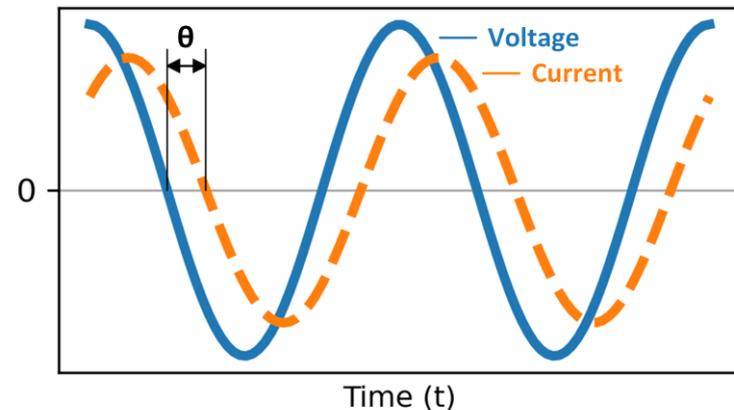
Voltage

Frequency (60 Hz)

$$I(t) = I \cdot \cos(\omega t - \theta)$$

Current

Phase Difference



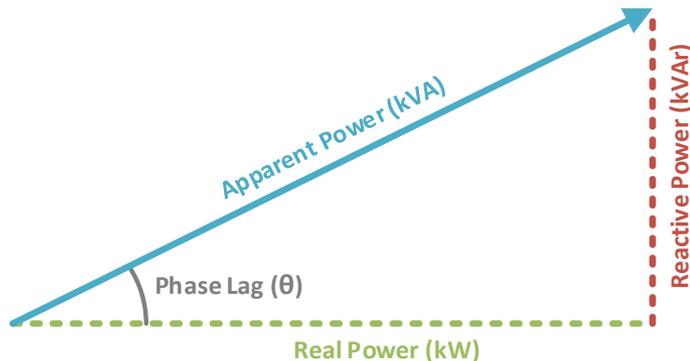


Power Factor Penalties

Power: $P(t) = V(t) \cdot I(t) = \dots \text{Math!} \dots =$

$$P(t) = \underbrace{P_{avg}}_{\substack{\text{Real Power} \\ \text{(kW)}}} \cdot (1 + \cos(2\omega t)) + \underbrace{Q}_{\substack{\text{Reactive Power} \\ \text{(kVAr)}}} \cdot \sin(2\omega t)$$

- Both real and reactive power are required to run your facility
- Utility must deliver **Apparent Power (S)** which is related to PF



$$S = \sqrt{P_{avg}^2 + Q^2} \quad S \geq P_{avg}$$

$$PF = \cos(\theta) = \frac{P_{avg}}{S}$$

The lower your PF, the more apparent power your utility must deliver!



Power Factor Penalties

- PF is usually listed on your bills
- PF penalties are rarely clearly listed on your bills
- Penalties depend on how you are billed for demand:

Billed for Real Power (kW)

$$\text{PF Adjusted Demand (AD)} = RD \times \frac{PF_{req}}{PF}$$

$$\text{PF Penalty} = C_d \times (AD - RD)$$

Billed on Apparent Power (kVA)

$$\text{PF Penalty} = C_d \times (BD - RD)$$

$$\text{PF Penalty} = C_d \times BD \times (1 - PF)$$



Penalized only if $PF \leq PF_{req}$



Penalized for any $PF < 1$

How Do You Fix Low PF?

- Nearly all facilities have low PF because of large motors used in their production process
- Windings act as large inductors causing current lag
- Install capacitor banks to offset inductive loads
- Two types of capacitors:
 - 1) Static (\$)
 - 2) Dynamic (\$\$)
- Fix baseload phase difference with static capacitors
- Fix remaining difference with dynamic capacitors



Wikimedia Commons



How Much Does Low PF Cost?

- Consider a facility with an average $PF_{avg} = 0.85$
- Demand cost is \$8/kW with not ratchet clause
- Utility requires a minimum $PF_{req} = 0.95$
- Average billed demand is $BD_{avg} = 850 \text{ kW}$

$$\text{Real Demand } (RD_{avg}) = BD_{avg} \times \frac{PF_{avg}}{PF_{req}} = 761 \text{ kW}$$

$$\text{PF Penalty} = C_d \times (BD_{avg} - RD_{avg}) \times 12 = \mathbf{\$8,544/yr}$$



Riders

- Several other charges can be listed on your bills
- **Riders** are modifications to your rate structure
- Some riders apply only certain months
- Usually very descriptive and for specific purposes



Transmission Cost Recovery Factor

Renewable Energy Development Fund \$



Nuclear Decommissioning Charge

Energy Efficiency Cost Recovery Factor \$



Fuel Cost Recovery Factor



Non-Energy Charges

- Some charges on your bills may not be related to consumption or demand
- Fixed charges are built into your rate structure but ensuring you have the right schedule can save costs
- Some charges can be avoided with a little planning



Customer Fees
Metering Fees
Etc.



Late Payment Fees
Insufficient Funds Fees
Etc.



Local Taxes
State Sales Tax
Etc.



Some states allow sales tax exemptions for manufacturers under certain conditions!



Rate Structures

- **Rate Schedules** are collections of pricing structures offered by your utility
- Choosing the right rate structure is critical for minimizing energy costs

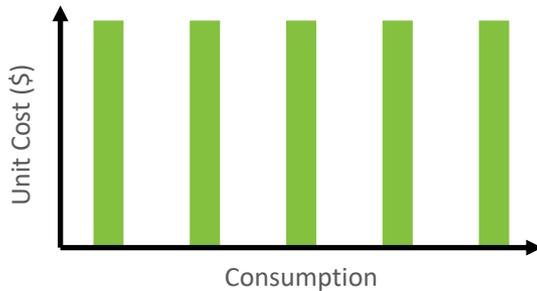
Rate Schedule	Requirements	Rates
Exterior Lighting	Outdoor areas not covered by street lighting.	Flat Rate by Lamp Type
Small General Service	Less than 10 kW of monthly demand.	Service Charge: \$15.25/customer First 600 kWh: \$0.03225/kWh All other kWh: \$0.02076/kWh
Medium General Service	Greater than 10 kW of monthly demand.	Service Charge: \$43.00/customer Demand Charge: \$2.20/kW First 10,000 kWh: \$0.03438/kWh All other kWh: \$0.02927/kWh
Large General Service	Demand greater than 100 kVA but less than 3,000 kVA.	Service Charge: \$156.00/customer Demand Charge: \$6.72/kVA Energy Charge: \$0.00787/kWh



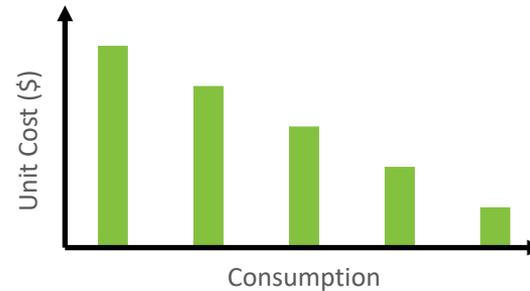
Rate Structures

There are several common pricing options:

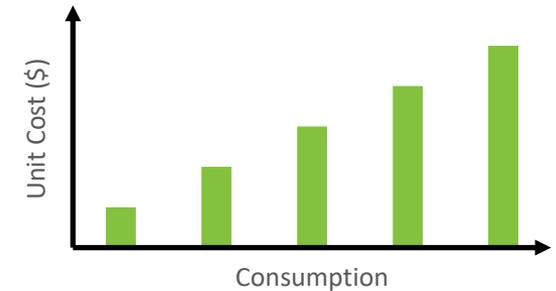
Uniform



Decreasing Block Rate

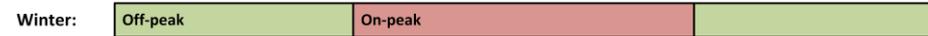
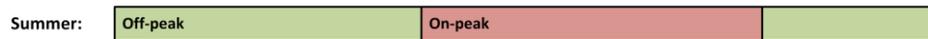


Increasing Block Rate

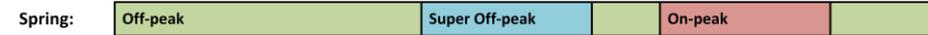


On-peak/Off-peak

Richmond Power & Light

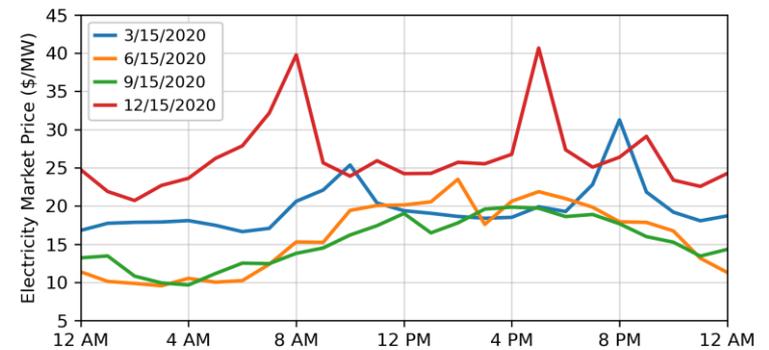


PG&E



12 AM 4 AM 8 AM 12 PM 4 PM 8 PM 12 AM

Real-time Pricing





Your Cost of Electricity

Blended Cost:

- Quick and easy way to estimate costs
- Only estimates consumption savings

$$C_{blend} = \frac{\textit{Total Electricity Costs}}{\textit{Total Energy Consumption}}$$

Marginal Cost:

- More detailed estimate of costs (consumption + demand)
- Requires knowing your rate structure

$$C_{mrg} = \textit{Energy Charge 1} + \textit{Energy Charge 2} + \dots$$

$$D_{mrg} = \textit{Demand Charge 1} + \textit{Demand Charge 2} + \dots$$



Your Cost of Electricity

Identify all the charges and how they are assessed...

> Date Billed: 3/26/2020
 > Account #: 1234-5678
 > Invoice: 32620-12345

**BETTER PLANTS
ELECTRIC INC**

Here to help you save.

Total Amount Due by 4/1/2020 \$32,446.48

Service for:
 Manufacturing Plant
 987 Sixth Avenue
 Oak Ridge, TN 37830

Meter #: J942U4L71
 Days on Bill: 30
 Total kWh: 421,855
 Billed Demand: 1,257 kW
 Actual Demand: 1,151 kW
 PF: 0.87

Customer Charge:		\$45.00
Metering Charge:		\$175.00
Energy Charge 1:	250,000 x 0.0625	\$15,625.00
Energy Charge 2:	171,855 x 0.0482	\$8,283.41
Energy Efficiency Cost Recovery:	421,855 x 0.0004	\$168.74
Transmission Charge 1:	1,257 x 2.2582	\$2,838.56
Transmission Charge 2:	1,257 x 0.3247	\$408.15
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Energy Subtotal:		\$31,841.49
Local Sales Tax:	0.25%	\$79.60
State Sales Tax:	1.65%	\$525.38
Late Payment Fee:		\$0.00
Taxes & Fees Subtotal:		\$604.99

Consumption Charges (per kWh)

- Energy Charge 1: \$0.0625
- Energy Charge 2: \$0.0482
- EE Cost Recovery: \$0.0004

Demand Charges (per kW)

- Transmission Charge 1: \$2.2582
- Transmission Charge 2: \$0.3247
- TRNS Cost Recovery: \$2.4849
- Nuclear DECOM: \$0.0079
- DISTRO Cost Recovery: \$0.4594

Other Charges:

- PF Penalty
- Customer & Metering Fees
- State and Local Sales Taxes



Your Cost of Electricity

Blended Cost:

$$C_{blend} = \frac{\text{Electricity Costs}}{\text{Energy Consumption}} = \frac{\$32,466.48}{421,855 \text{ kWh}} = \frac{\$0.077}{\text{kWh}}$$

Marginal Costs:

- For 4 months, consumption never reaches the block 2 rate...

$$C_{mrg,yr} = \frac{4}{12} \times EC1 + \frac{8}{12} \times EC2 + EECRF$$

$$= 0.33 \times \frac{\$0.0625}{\text{kWh}} + 0.67 \times \frac{\$0.0482}{\text{kWh}} + \frac{\$0.0004}{\text{kWh}} = \frac{\$0.0530}{\text{kWh}}$$

$$D_{mrg} = TC1 + TC2 + TCRF + NDC + DCRF$$

$$= \frac{\$2.2582}{\text{kW}} + \frac{\$0.3247}{\text{kW}} + \frac{\$2.4849}{\text{kW}} + \frac{\$0.0079}{\text{kW}} + \frac{\$0.4594}{\text{kW}} = \frac{\$5.5351}{\text{kW}}$$



Opportunities for Cost and Energy Savings



Demand Management



Power Factor Correction



Recreating Your Bills



State Sales Tax Exemptions



Avoiding Late Fees



Tracking Energy Consumption



Production/Load Factor Analysis



Tracking Your Electricity Usage

- DOE offers software tools to track energy usage
- Identify trends, anomalies, and opportunities

DOE Advanced Manufacturing Office
Energy Footprint [v1.1]
Developed for the DOE Advanced Manufacturing Office
 QUESTIONS, COMMENTS, or ISSUES
 email: eGuidefeedback@ee.doe.gov

Description
 The Energy Footprint tracks energy consumption by source, factors affecting to energy consumption, and specific energy uses on a monthly basis for 1 or multiple years.

Plant Name
 Additional Details

Worksheets (click to goto)
 Energy Consumption Tables Charts EC vs RV
 Relevant Variables Tables Charts
 Energy Uses Tables Charts
 EnPI Table

First Month: Jan
 Current Year*: 2015 *of first month
 Number of Years: 3

Select Energy Sources

Select	Type	Units	# Used
<input checked="" type="checkbox"/>	Electricity	kWh site	1
<input checked="" type="checkbox"/>	Electricity Demand	kW	
<input checked="" type="checkbox"/>	Electricity Fees	none	
<input checked="" type="checkbox"/>	Natural Gas	Dtherm	1
<input checked="" type="checkbox"/>	LPG	MMBtu	
<input type="checkbox"/>	#1 Fuel Oil	MMBtu	
<input type="checkbox"/>	#2 Fuel Oil	MMBtu	
<input type="checkbox"/>	#4 Fuel Oil	MMBtu	
<input type="checkbox"/>	#6 Fuel Oil	MMBtu	
<input type="checkbox"/>	Coal	MMBtu	
<input type="checkbox"/>	Wood	MMBtu	
<input type="checkbox"/>	Paper	MMBtu	
<input type="checkbox"/>	Other Gas	MMBtu	
<input type="checkbox"/>	Other Energy	MMBtu	
<input type="checkbox"/>	custom 1 (edit)	none	
<input type="checkbox"/>	custom 2 (edit)	MMBtu	
<input type="checkbox"/>	custom 3 (edit)	none	

* active Energy Sources cannot be unselected

Select Relevant Variables Tracked

Select	Type	Units	# Used
<input checked="" type="checkbox"/>	Production	count	
<input checked="" type="checkbox"/>	Heating Degree Days	HDD	1
<input type="checkbox"/>	Cooling Degree Days	CDD	
<input type="checkbox"/>	Customers Served	count	
<input type="checkbox"/>	Production Hours	hours	
<input type="checkbox"/>	Facility Operating Hours	hours	
<input type="checkbox"/>	Water Usage	Tgal	
<input type="checkbox"/>	Occupancy	count	
<input type="checkbox"/>	custom 2 (edit)	misc	
<input type="checkbox"/>	custom 3 (edit)	misc	
<input type="checkbox"/>	custom 4 (edit)	misc	
<input type="checkbox"/>	custom 5 (edit)	misc	

* Related Factors cannot be unselected

MMBtu (primary)

1 kWh site = 0.010228 FOR REFERENCE: These energy conversion factors are used only
 1 Therm = 0.1
 1 Dtherm = 1 to calculate the total primary
 1 MMBtu = 1 energy consumption and are not
 1 GJ = 0.9471 otherwise used.

version: 1.1
 build date: 2016.04.24

Energy Footprint Tool

General Energy Performance Results

The table below shows the unadjusted and adjusted energy consumption and intensity data. The models used to adjust the data for each energy source are shown below the plots and on the individual sheets for each energy source. Note that the tool selects the model that is appropriate for the SEP Program and has the highest adjusted R-squared value.

	2007	2008	2009
Actual Electricity (MMBTU)	1,634,358	1,265,861	1,050,028
Actual Natural gas (MMBTU)	960,346	758,811	643,299
TOTAL (MMBTU)	2,594,704	2,024,672	1,693,426

Adjustment Method	Model Year	Forecast	Forecast
Modeled Electricity (MMBTU)	1,634,358	1,304,164	1,153,191
Electricity (MMBTU) Annual Savings	0	38,383	103,864
Modeled Natural gas (MMBTU)	960,346	797,194	724,095
Natural gas (MMBTU) Annual Savings	0	38,383	70,714
Total Modeled Energy Consumption (MMBTU)	2,594,704	2,101,358	1,867,204
Total Improvement in Energy Intensity (%)	0.00%	3.65%	9.31%
Annual Improvement in Energy Intensity (%)	0.00%	3.65%	5.66%
Total Energy Savings since Baseline Year (MMBTU/Year)	0	76,686	173,778
Cumulative Savings (MMBTU)	0	76,686	250,464
New Energy Savings for Current Year (MMBTU/year)	0	76,686	97,091
Adjustment for Baseline Primary Energy Use (MMBTU/year)	0	-493,346	-727,500

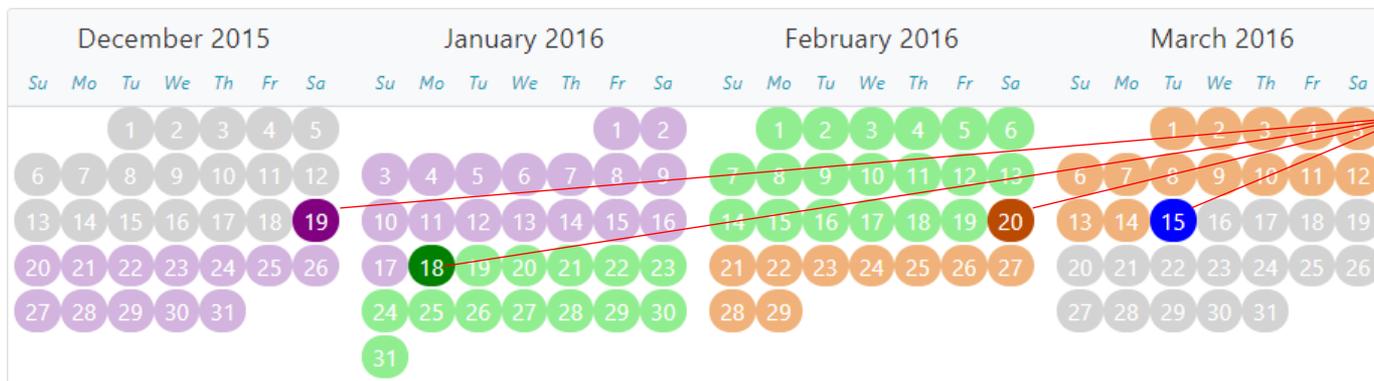
Energy Use	Model to	Variable	Variable	R2	Adjust	Model	Formula
1 Electricity (MMBTU)	TRUE	Production	0.000234	0.756995	0.732695	0.000234	(5.086166746649 * [Production]) + 20110.25
1 Natural gas (MMBTU)	TRUE	Production	4.13E-06	0.914872	0.895954	1.53E-05	(2.560004576545 * [Production]) + (211.520605238538 * [Temperature]) + 7322.73
		Temperature	0.013011				

Energy Performance Indicator Tool



Calendarization

- Billing periods depend on when the utility reads your electricity meters
- Normalizing electricity data for billing periods is known as ***Calendarization***
- Divide consumption by days on bill and allocate energy to calendar month



**Bills Start
Mid-month**

30 days

33 days

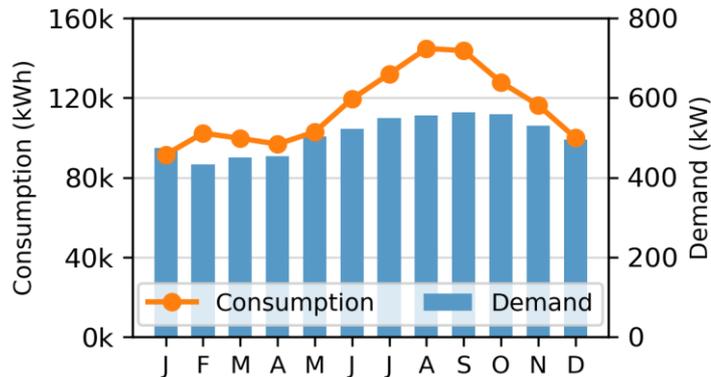
24 days



Load Factor Analysis

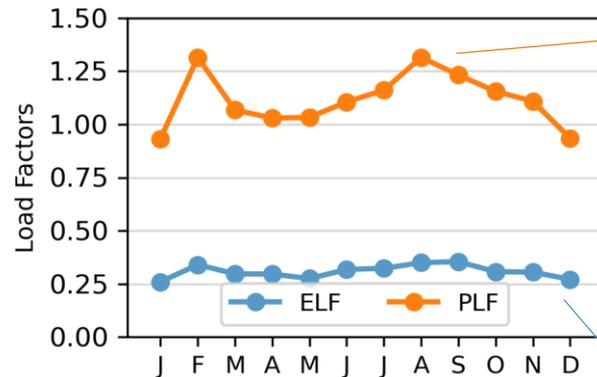
- **Electrical Load Factor (ELF):**
Ratio of monthly kWh consumption and maximum possible consumption

$$ELF = \frac{\text{Consumption}}{\text{Demand} \times \text{Billing Hours}}$$



- **Production Load Factor (PLF):**
Ratio of monthly kWh consumption and maximum production consumption

$$PLF = \frac{\text{Consumption}}{\text{Demand} \times \text{Production Hours}}$$



PLF >> 1
Equipment is being left on

ELF ≈ 0.2
One-Shift



Questions?



Future Webinars

Additional Questions:

- Pete.Langlois@ee.doe.gov
- Pricecr@ornl.gov
- Eli.Levine@ee.doe.gov

Reminder:

- Next webinar is Thursday, Oct. 14th from 1-2pm ET
- Understanding Your Electricity Bills
- Register at Yesevents.com/EnergyAwareness